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Analyzing Safety Culture in Sri Lankan Industrial Chemical Laboratories

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ABSTRACT

Background: A laboratory where chemicals are handled can be considered a hazardous environment, and hence, prudent practices should be strictly enforced. If not, deadly accidents and incidents could occur due to a lack of safety practices and poor safety culture. The purpose of this study is to analyze the existing safety culture and propose potential recommendations to enhance the level of safety education in the chemical laboratories in the Western Province of Sri Lanka.

Methods: A survey questionnaire was administered among the laboratory supervisors of the chemical laboratories in the Western Province of Sri Lanka in 2019.

Results: Even though 80 surveys were distributed among prospective participants, only 46 surveys were submitted, which is 58% of the response rate. Most of the individuals who participated in the survey were females below 35 years old, and approximately 96% of the participants had at least one year of working experience in the same laboratory setting. The majority considered safety as an important factor that requires further improvements with third-party safety inspections; however, 54% of the respondents mentioned that those inspections were conducted by the employees from their laboratory.

Conclusion: From the study, it has been discovered that employees have knowledge of safety culture to a certain extent. A significant percentage (83%) of participants believed that further safety measures are required for a safer laboratory. However, the study revealed that the attitudes of some employees should be changed to have a better safety culture. Hence the authors would like to suggest having annual training sessions and well-formulated safety policies to improve the safety culture.

1. Introduction

A chemical laboratory can be considered a dangerous workplace if proper safety practices are not followed and implemented. In Sri Lanka and worldwide, many accidents ranging from minor injuries to deaths occurred in chemical laboratories due to a lack of safety culture [1–5]. Those events cannot be ignored as they raise concerns about the acceptable levels of safety that should be followed by all stakeholders attached to a chemical laboratory. Hence, it is important to ensure that all the laboratory staff receives a suitable safety education. With a prudent safety culture, the laboratory is a safe workplace with a minimum level of risk to any individual or an instrument.

The safety culture can be defined as the commitment of an organization to prioritize safety over other processes that might be beneficial to the working environment [6,7]. An organization that maintains a positive safety culture can be considered as a healthy working environment; however, a negative safety culture can seriously impact the workplace and workers, leading to high risks such as chronic diseases, loss of limbs, or sometimes death [8,9]. Some laboratories have well-developed safety procedures, also known as safety policies, while others may not have any systematic procedures to reduce the chemical exposures according to the hierarchy of controls. Therefore, special precautions should be taken when hazardous chemicals are handled [10]. It is the responsibility of the management of respective industries to develop a safety policy to safeguard the employees by adopting globally acceptable standards [11–14].

It is evident that industrial settings have more experienced staff to manage tasks more efficiently and effectively with fewer incidents

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compared to academic institutions [15]. Further, a recent study on laboratory safety in academic institutions by Ayi and Hon demonstrated that most individuals do not assess risks before starting a chemical process that causes unexpected damages [16]. It has been reported that conducting annual training programs to teach and train new procedures, rules, and regulations would be beneficial for the industries to create awareness of the safety culture [17–19].

Although it is highly recommended that chemical laboratories maintain basic or minimum safety standards at a positive state, not much is known in the Sri Lankan context. As far as authors are aware, there is no literature available on chemical safety studies in Sri Lanka, and this could be the first of such. However, there is literature available on pesticide and occupationally related incidents, which demonstrate improper use of chemical-related products in agriculture [2]. Therefore, the focus of this study is to understand the level of safety culture established in chemical laboratories in the Western Province of Sri Lanka and propose recommendations to educate employers and employees.

The remainder of this study is organized in the following sections. The research methodology is explained in Section 2. The results of the current study with data analysis are provided in Section 3. Section 4 of the article provides a detailed discussion of the current study, and Section 5 is dedicated to the conclusion of this research.

2. Methods

This study was conducted to determine the perceptions of the laboratory workers in chemical industries about safety practices, safety attitudes, and their emergency preparedness. A hard copy of the survey questionnaire with 34 questions was administered as a data collection tool with the assistance of students who attended industrial training during the period from January 2019 to July 2019. The laboratory supervisors, who were full-time workers, completed surveys and confidentially sent them to the authors. Although the data were collected anonymously, ethical approval was taken from the respective industries and participants before conducting the study. The survey was conducted in English.

This survey questionnaire adapted some of the questions from the 2012 survey on "Laboratory safety attitudes and practices: A comparison of academic, government, and industry researchers" [15] and additional questions were prepared to cover the use of personal protective equipment, safety culture, etc. Before administering the survey, the validity of the items was evaluated by three experts.

The survey questionnaire consists of five parts (A-E) with multiple answer questions, yes/no type questions, and open-ended questions. Part A (questions 1 to 7) of the survey was mainly focused on demographic data of the participants, while part B (questions 8 to 13) consisted of questions based on workers' attitudes and perceptions toward laboratory safety. Part C (questions 14 to 25) was focused on workers' laboratory practices, while part D (questions 26 to 30) was dedicated to laboratory management. The final part (questions 31 to 34) of the survey covered workers' opinions about laboratory safety as applicable to the employer's working environment.

The collected data were analyzed using Microsoft Excel (2007), and the percentage for each answer was calculated by dividing the number of responses received for that question by the total number of respondents. Collected data from this study were compared with some selected questions from the 2012 survey [15].

3. Results

As a policy, the industrial training module would be supervised by managerial level employees who possess minimum education of master's degree in the field. Although 80 surveys were distributed, only 46 participants submitted completed surveys that were approximately 58% of the total. The response rate was relatively high compared to most of the similar surveys conducted online and via email [20]. Table 1 shows the percentage of response for each question administered.

According to **Q** 1 in demographic data, 31 participants were females while 15 were males. All the participants were in the age range (**Q 2**) of 30 to 35, and most of the participants engaged in research projects while the others were engaged in industrial and other routine work (**Q 3**). In **Q 3,** the participants were allowed to express their perspective on the area of working other than academia, research, or industry. This question was given purposely, and the main objective was to seek whether the workers belong to other activities other than those listed in the survey. Although nine respondents (20%) answered as "other," no rationalization was given to support their choice. Most participants had a working experience of more than 10 years (**Q** 4), and out of them, 80% have been working in the same laboratory throughout that period (**Q** 5). According to the **Q** 6, more than 50% of participants spent 40 hours or more per week handling chemicals in the laboratory, and 89% of the participants believed that the level of risk was either moderate or low (**Q** 7).

According to the collected data (**Q** 8), the majority believed that safety was very important for their laboratory work, while 7% considered it was quite important. About 87% (**Q** 9) of participants supported the fact that inspections can have a positive impact on safety, while a few participants believed that safety was slightly improved by inspections. About 89% of the participants (**Q** 10) believed that the laboratory inspections was carried out at different times of the year would not affect the productivity (**Q** 16).

Safety inspections (Fig. 1) are an integral part of any laboratory, and about 50% of the participants reported that safety inspections were conducted in the laboratory once a month, while 30% reported such inspections were done once a quarter. About 15% reported that such inspections were conducted annually, and the remainder was not aware of such inspections. Although it was unfortunate to see that about 4% did not know anything about the safety inspections, it was good to observe that 96% of the participants had an idea of safety inspections which is an integral part of prudent laboratory practices.

According to the **Q** 17, about 54% of the respondents stated that the safety inspections were carried out by the employees from the same laboratory and only 17% said that they were conducted by a third party; 20% of the participants (**Q** 11) responded that safety was of equal importance as of other lab priorities such as administration work, cleaning, and any chemical-related procedures. Although 39% of the participants thought that the safety procedures in the laboratory were stringent, about 33% of them claimed that the safety procedures should be more stringent (**Q** 12). According to **Q** 13, 93% of respondents reported that their safety culture could have been developed compared to past years.

About 96% of the participants (**Q** 14) reported that the employers had taken steps to avoid or minimize laboratory-related injuries. The data (**Q** 15) demonstrated that all the participants had been given personal protective equipment (PPE) by the employers, which was indeed a good sign of a positive safety culture. Although 93% of the participants were able to use the PPEs (**Q** 27), only 57% of the participants (**Q** 28) used them regularly, as shown in Fig. 2.

About 78% of the participants had access to their safety records as per **Q** 18, which was indeed a good sign of safety culture; however, 22% of the participants did not have access. **Q** 19 and **Q** 20 demonstrate that the respondents received general and specific safety training on hazards in the laboratory. However, according to **Q** 19, it was questionable that about 10% of the participants did not

Table 1
Opinions of the participants to the survey questionnaire

Question	Category	Subcategory	No.	Response frequency
Part A				
Q 1	Gender	Male	15	32.61%
		Female	31	67.39%
Q 2	Age	Under 18 years	0	0.00%
		18–20 years	0	0.00%
		21–25 years	1	2.17%
		26–30 years	8	17.39%
		31–35 years	14	30.43%
		36–40 years	11	23.91%
		41–50 years	10	21.74%
		51–60 years	2	4.35%
Q 3	Area of working	Academic	0	0.00%
		Industry	10	21.74%
		Research	27	58.70%
		Other (specify)	9	19.57%
Q 4	Length of time spent working in any laboratory setting	Less than 5 months	1	2.17%
		5–11 months	0	0.00%
		1–2 years	5	10.87%
		3–4 years	6	13.04%
		5–10 years	14	30.43%
		11+ years	20	43.48%
Q 5	Length of time spent working in current laboratory setting	Less than 5 months	2	4.35%
		5–11 months	0	0.00%
		1–2 years	9	19.57%
		3–4 years	3	6.52%
		5–10 years	16	34.78%
		11+ years	16	34.78%
Q 6	Average Time spent handling chemicals in the laboratory	1–10 hrs/week	6	13.04%
		11–20 hrs/week	3	6.52%
		21–30 hrs/week	13	28.26%
		31–40 hrs/week	6	13.04%
		40 hrs/week and more	13	28.26%
		Not applicable	5	10.87%
Q 7	Self-perceived level of risk in laboratory	High	5	10.87%
		Moderate	33	71.74%
		Low	8	17.39%
Part B				
Q 8	How important is safety to you	very important	43	93.48%
		quite important	3	6.52%
		moderately important	0	0.00%
		not important	0	0.00%
Q 9	Impact of inspections on laboratory safety	Safety is greatly improved by inspections	40	86.96%
		Safety is slightly improved by inspections	6	13.04%
		Inspections have no significant impact on safety	0	0.00%
		Safety is slightly compromised by inspections	0	0.00%
		Do not know	0	0.00%
Q 10	Laboratory inspections and regulations negatively impact my lab productivity	Agree	5	10.87%
		Disagree	39	84.78%
		Neither agree nor disagree	2	4.35%
Q 11	Which of the following statements best describes your laboratory regarding safety?	Safety is paramount and takes precedence over all other laboratory priorities	18	39.13%
		Safety is very important	19	41.30%
		Safety is of equal importance to other laboratory priorities	9	19.57%
Q 12	Safety procedures in the laboratory are	Stringent	18	39.13%
		About right	13	28.26%
		Should be more stringent	15	32.61%
		Do not know	0	0.00%
Q 13	The overall safety in my laboratory could be improved past years	Agree	43	93.48%
		Disagree	1	2.17%
		Neither agree nor disagree	2	4.35%
Part C				
Q 14	Appropriate safety measures have been taken in my laboratory to protect employees from injury	Agree	44	95.65%
		Disagree	1	2.17%
		Do not know	1	2.17%
Q 15	All the employees are provided with personal protection equipment	Yes	46	100.00%
		No	0	0.00%
Q 16	How often are safety inspections carried out in your laboratory	At least once a month	23	50.00%
		At least once a quarter	14	30.43%
		At least once a year	7	15.22%
		Do not know	2	4.35%
Q 17	Who does the safety inspections?	Employees from the lab	25	54.35%
		Outside employees	13	28.26%
		Third party	8	17.39%

Table 1 (*continued*)

Question	Category	Subcategory	No.	Response frequency
Q 18	I have access to the data and records which are tracked regarding my laboratory's safety and compliance	Agree Disagree Neither agree nor disagree	36 0 10	78.26% 0.00% 21.74%
Q 19	Have you received general safety training at your current laboratory?	Yes No	41 5	89.13% 10.87%
Q 20	I received safety training on the specific agent/ hazards I work with	Agree Disagree Neither agree nor disagree	40 5 1	86.96% 10.87% 2.17%
Q 21	In your current laboratory, are you aware of what to do in case of emergencies?	Yes No	45 1	97.83% 2.17%
Q 22	Do you know the location of safety equipment?	Yes No	46 0	100.00% 0.00%
Q 23	What is the frequency of people working alone in the laboratory?	Every day At least once a week A couple of times a month Less than once a month Do not know	7 11 5 16 7	15.22% 23.91% 10.87% 34.78% 15.22%
Q 24	My supervisor or principal investigator regularly checks to make sure I am performing my laboratory duties in a safe fashion using proper safety equipment.	Agree Disagree Neither agree nor disagree	40 2 4	86.96% 4.35% 8.70%
Q 25	In the time that you have been at your current laboratory, have your ever sustained an injury of any kind?	Yes No	15 31	32.61% 67.39%
Part D				
Q 26	Has the Risk assessment been conducted in laboratory before?	Risk is formally assessed by third party Risk is assessed using my own format Risk is informally assessed No risk is assessed	25 4 14 3	54.35% 8.70% 30.43% 6.52%
Q 27	In general, I feel that I am able to use the required PPE properly	Agree Disagree Neither agree nor disagree	43 3 0	93.48% 6.52% 0.00%
Q 28	All the laboratory staff use PPE usage when performing laboratory work	All the time Most of the time Some of the time Rarely Do not know	26 10 10 0 0	56.52% 21.74% 21.74% 0.00% 0.00%
Q 29	I feel comfortable speaking to my supervisor or principal investigator about safety concerns	Agree Disagree Neither agree nor disagree Do not know	43 0 3 0	93.48% 0.00% 6.52% 0.00%
Q 30	I have not reported any accident/incident/near miss to my supervisor or principal investigator.	This has happened only once This has happened on more than one occasion This has never happened	5 5 36	10.87% 10.87% 78.26%
Part E				
Q 31	My laboratory is a safe place to work	Agree Disagree Neither agree nor disagree	41 0 5	89.13% 0.00% 10.87%
Q 32	Safety is utmost important in my laboratory	Takes precedence over all other lab duties Is of equal importance to other lab priorities Less important than experiment/low priority	25 21 0	54.35% 45.65% 0.00%
Q 33	Safety rules negatively impact productivity	Strongly agree/agree Strongly disagree/disagree Neither agree nor disagree	3 35 8	6.52% 76.09% 17.39%
Q 34	The level of risk associated with laboratory work is	Low-very Low Moderate High-very high	13 26 7	28.26% 56.52% 15.22%

have any safety training. On the other hand, 98% of participants were aware of the emergency procedures (**Q** 21) and the location of safety equipment (**Q** 22). Some participants (**Q** 23) used to work alone, as shown in Fig. 3, depending on the nature of work they are involved in. However, answering "do not know" to **Q** 23 indicated less awareness of his/her subordinates.

It is appreciated to note that majority of supervisors regularly check the laboratory (**Q** 24) to ensure workers perform their tasks in a safe manner using proper safety equipment. As per **Q** 25, 33% of the participants sustained injuries while they were working in the laboratory, which could be reduced by maintaining proper laboratory safety.

According to **Q** 26, about 93% responded that a risk assessment had been conducted in the laboratory either formally or informally. Although 93% of the participants were confident in communicating with supervisors (**Q** 29), only 22% of them were comfortable reporting the accidents, incidents, or near misses (**Q** 30), which contradicted the previous statement in **Q** 29.

About 89% of the participants (**Q** 31) believed that their laboratory was a safe place to work (Fig. 4), and all participants considered that safety was equal or above their other laboratory priorities (**Q** 32). However, approximately 11% were not confident about the safety precautions or procedures implemented by the laboratory. Most of the participants (i.e., 76%) felt that the safety rules did not impact their laboratory activities, according to **Q** 33. In general, 72% of participants believed that the level of the risk in their laboratory activities was to be moderate, or above according to **Q** 34.

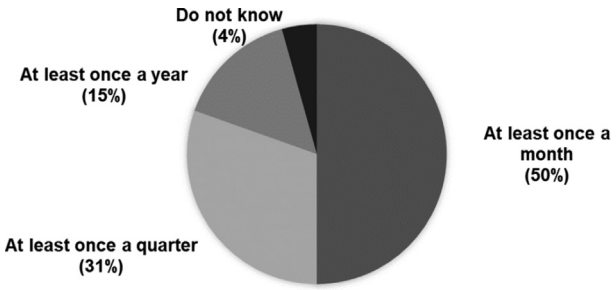

Fig. 1. Frequency of safety inspections.

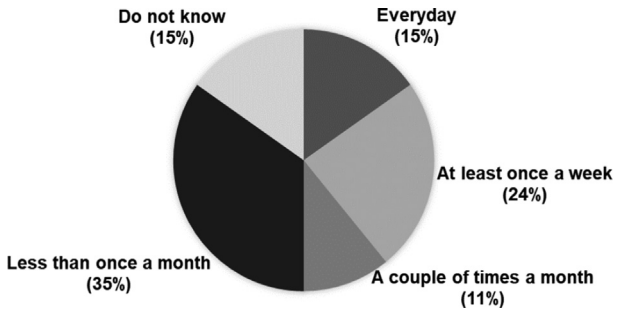

Fig. 3. Frequency of people working alone in the laboratory.

4. Discussion

As far as the authors are aware, the safety culture in chemical laboratories in Sri Lanka had never been evaluated before, and this might be the first of such. Our study was mainly focused on industrial chemical laboratories in the Western Province of Sri Lanka, where most of them are located. The response rate of the study was 58% which is considered high in comparison to the response rate of the pilot study on laboratory safety awareness, practice, attitude, and perception of tertiary laboratory workers in Hong Kong [20]. This may be because the distribution of the survey was done in person instead of using online methods such as emails or other online survey platforms. Most of the respondents were aware of the laboratory safety culture as they have been working in the field for a considerable time. However, according to the results, a significant number of participants demonstrated that their incompetency with basic safety rules according to Figs. 2 and 3. This would negatively impact both workers and the industry unless proper training is provided. Therefore, the authors suggest providing suitable training sessions and educating the employees about basic safety rules before assigning laboratory work.

Indicating that they never had a risk assessment shows the level of safety culture in Sri Lankan laboratories, which should be immediately rectified before any incident occurs [1]. Further, the survey demonstrated that the safety inspections were not carried out by third-party auditors, which were alarming. These perceptions can negatively influence workers as they tend to pay less attention to safety. Hence, employers and employees need to follow the hierarchy of control to protect everyone in the organization from hazards. Although the first-party inspections (**Q** 17, 54%) provide valuable information, it is highly recommended to conduct third-party inspections to obtain better opinions on safety. In general, industries do not carry out such inspections simply because they would be an extra burden for the employer. However, the management may not be aware that the compensation for an accident or incident can be enormous compared to the cost of a third-party inspection. This situation can be avoided by having third-party inspections along with the first-party or second-party inspections. Lack of strong commitment and strict laws in a country could encourage industries to easily avoid such inspections, and hence, authorities should implement strict rules and regulations. This is clear when some participants (**Q** 33, 7%) responded that safety rules negatively impact their lab productivity which is questionable and alarming. This reflects the lack of safety education and commitment toward the safety culture in the country. However, most participants (**Q** 9, 87%) do have a positive attitude toward safety inspections as they believe the safety can be greatly improved by inspections which is a plus point. Astonishingly, some of the laboratory individuals, as well as their managers, did not understand the importance of safety and safety rules (**Q** 11, **Q** 23, and **Q** 28). Moreover, this fact supports their reluctance to have third-party inspections. Regardless of that, a considerable number of participants feel that the safety should be stringent or more stringent (**Q** 12, 72%), and it could have been improved as the workers may be less satisfied with the existing safety procedures. Sometimes maintaining occupational safety and health standards would not be adequate to maintain a proper safety culture for a chemical laboratory as the guidelines cover a wide range of industries. Hence the rules and regulations must be redefined without destroying the original goals. Approximately 96% of participants (**Q** 14) claimed that the appropriate safety measures had been taken to protect employees from injuries, which is a satisfactory response. Some participants (**Q** 25, 33%) stated that accidents/injuries had happened to them while working in the laboratory, which reflected that those industries do need stringent safety practices. Therefore, it is recommended to read, study, and review a safety document such as a safety data sheet (SDS) before any activity to learn its adverse effects and be aware of basic first aid training to minimize the extent of the damage. Most

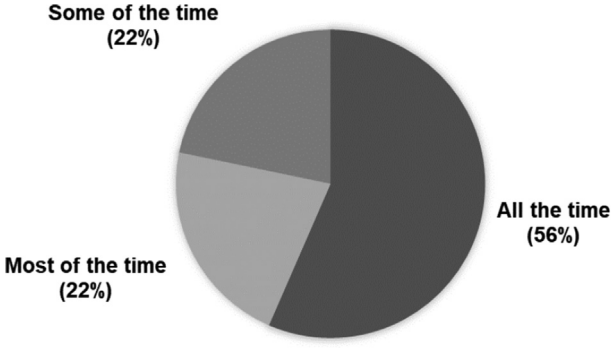

Fig. 2. Usage of PPE when performing laboratory work.

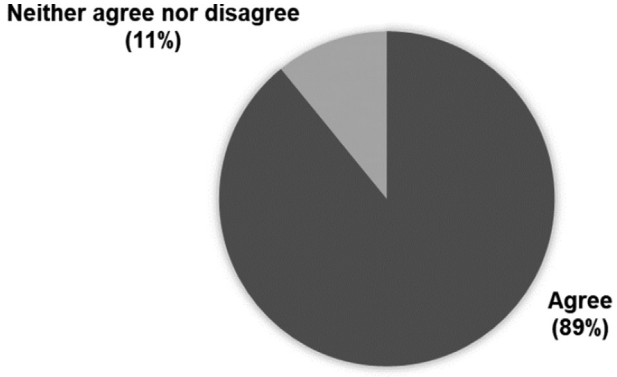

Fig. 4. The laboratory is a safe place to work.

Table 2
Comparison of 2012 study with 2019 Sri Lankan study

Questions	Options	2012 study (%) ($n = 113$) [15]	SL study (%) ($n = 46$)
My laboratory is a safe place to work	Agree	90	89
	Disagree	7	0
	Neither agree nor disagree	3	11
Safety is utmost important in my laboratory	Takes precedence over all other lab duties	67	54
	Is of equal importance to other lab priorities	20	46
	Less important than experiment/low priority	10	0
Safety rules negatively impact productivity	Strongly agree/agree	16	7
	Strongly disagree/disagree	64	76
	Neither agree nor disagree	20	17
The level of risk associated with laboratory work is	Low-very Low	55	28
	Moderate	38	57
	High-very high	7	15

n, number of participants.

participants (**Q** 29, 93%) said they were comfortable speaking with their supervisors regarding safety, but still, many participants (**Q** 30, 78%) had not reported accidents/incidents to their supervisor, which was contradictory. This indicates that there is no proper practice to report any incident, near miss, or an accident regardless of the level of risk, which is not acceptable. The authors believe that the relevant authorities should take initiatives to implement prudential safety practices in the future.

Part E (**Q** 31- **Q** 34) of the current survey focused on workers' opinion about laboratory safety and were compared with the 2012 survey. Since the responses received were mainly from industrial research and development laboratories, the data were compared only with the results obtained for the industrial sector of the 2012 study [15].

According to results (Table 2; Fig. 5), 89% of the participants from both studies believed that their laboratory was a safe place to work, which was 90% in the 2012 study. However, in the current study.

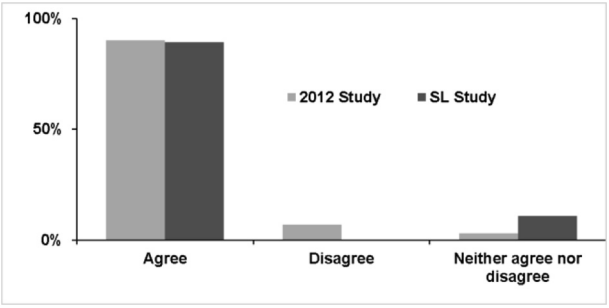

Fig. 5. A comparison of 2012 study and Sri Lankan study: "My laboratory is a safe place to work."

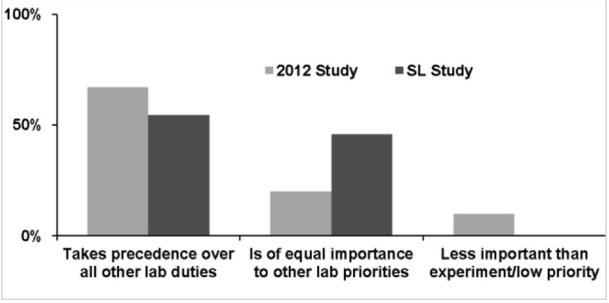

Fig. 6. A comparison of the 2012 study and Sri Lankan participants' responses to the question "Safety is of utmost importance in my laboratory."

11% of participants did not agree or disagree with the statement. With a feeling of insecure environment, it is obvious that workers cannot perform their duties efficiently and effectively.

According to results (Table 2, Fig. 6), in both studies, more than half of the participants agreed that safety was of utmost importance over other laboratory priorities. Further, no respondent in the current study considered safety was less important than other duties, while the 2012 survey had 10% of respondents who agreed with the statement.

According to results (Table 2, Fig. 7), both 2012 and current study participants had a similar opinion on the impact of safety rules on laboratory productivity. Further, an approximately similar percentage of participants responded as "neither agree nor disagree," which is interesting to note, as shown in Fig. 7.

As seen in (Table 2, Fig. 8), most participants from the current study (**Q** 34, 85%) believed that the risk was moderate and low, while 93% of 2012 survey participants agreed with that statement.

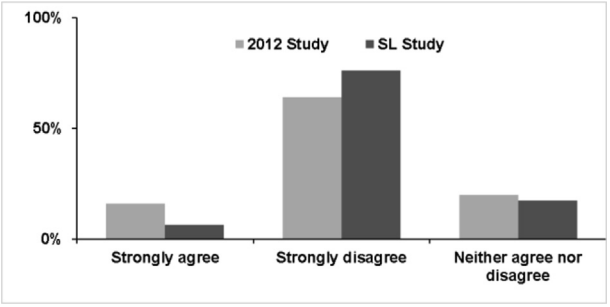

Fig. 7. A comparison of 2012 study and Sri Lankan Participants' response to the question "Safety rules negatively impact productivity."

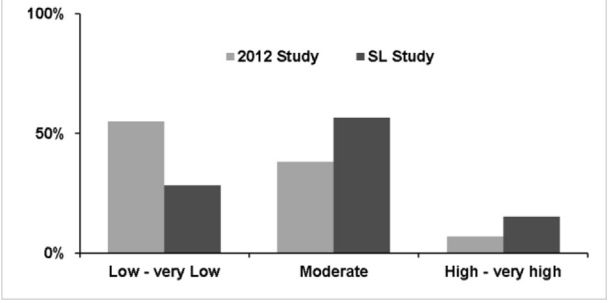

Fig. 8. A comparison of the 2012 study and Sri Lankan Participants' response to the question "The level of risk associated with laboratory work is."

5. Conclusion

This study shows the opinion of employees from industrial chemical laboratories located in the Western Province in Sri Lanka. About 83% believed that their laboratories pause high and moderate risk, which demonstrates that further safety measures are required. Therefore, the authors would like to suggest that those laboratories should formulate a suitable safety policy to minimize such incidents. According to Part B of the survey, most respondents agreed on the safety rules that were needed to be applied. However, about 32% believed that the safety rules should be further stricter, which reflects there are some gaps for improvement in their safety culture. Hence, the authors suggest the management of respective laboratories take steps to strengthen the safety culture with recent developments. Conversely, a small percentage (15%) believed that the productivity of their laboratories would decrease with the implementation of safety rules. Therefore, it is essential to educate such employees by organizing tailor-made training programs conducted by safety professionals to eradicate such beliefs. Although 95% of the employees were given PPE, it was discovered a higher percentage (i.e. 32%) of accidents were due to a lack of awareness of PPE and its usage. It is strongly recommended to train them on the correct use of PPE and how to inspect the PPEs for defects before use. Although 95% of participants accepted their laboratories had safety inspections at least once a year, about 83% of them were carried out by the employees of the same establishment. For having constructive criticism, it is highly recommended to include third party inspections as well. The authors believe that the responsible bodies should distinguish suitable safety professionals who are competent to carry out such tasks without being biased. The study further discovered that there are still some gaps to be filled, such as not reporting all incidents in the laboratory although they were comfortable speaking to their supervisors. Hence, the authors believe this negative mindset should be corrected by addressing all pillars in safety culture. Finally, the authors would like to suggest that future studies of this nature must be extended to the academic laboratories in Sri Lanka, which would further increase the safety awareness among individuals who work in chemical laboratories.

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Conflicts of interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.shaw.2021.11.001.

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